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Translation of [0008] to [0011] in Detailed Explanation of Specification

[0008] When forming a heterojunction bipolar transistor for both purposes described above, an element having an electric charge equal to that of a constituent element is added in addition to the constituent elements determining an energy forbidden band gap and an impurity element determining a conductivity type. Specifically, indium or antimony is added into a base of a heterojunction bipolar transistor. Further, phosphorus, indium, indium and phosphorus, antimony, or antimony and phosphorus are added into an emitter of the heterojunction bipolar transistor. Moreover, phosphorus, indium, indium and phosphorus, antimony, or antimony and phosphorus are added into a collector of the heterojunction bipolar transistor. As a result of these, a degree of lattice strain of the base or the emitter can be set within a certain range.

[0009]

[Function] A relationship between a degree of lattice strain of the base and a lifetime of a heterojunction bipolar transistor when the equal electric charge-element is added will be explained below by using an example in the

case of the addition of indium. Fig. 1 shows an example of a construction of a heterojunction bipolar transistor in which an indium added, carbon doped p-type GaAs base layer 13 is used by adding indium into the carbon doped p-type GaAs base layer 3 in Fig. 5. In this case, a device lifetime is quite variable depending on the degree of base lattice strain of the base Δa (%) = $(a_B-a_C)/a_C$ (wherein a_B is a lattice constant of the base and a_C is a lattice constant of the collector) as shown in Fig. 8. That is, the base layer containing carbon is added with an indium so as to set the degree of lattice strain of the base on the basis of the lattice constant of the collector (a smaller lattice constant of the two layers contacting with the base layer, i.e. the emitter and collector layers, by comparison) at the range of $0 < \Delta a/a < +8*10^{-4}$, and thereby the lifetime of the heterojunction bipolar transistor can be increased by a factor of 10 or more. As a result, as shown in Fig. 9, the heterojunction bipolar transistor has a large current amplification factor at the initial and no drop in the current amplification ratio with time compared with the conventional heterojunction bipolar transistor to which no indium is added.

[0010] This shows that a density of a non-radiative recombination center in the GaAs is reduced by adding indium to set the lattice strain of the base layer within

the predetermined range, and even if a non-radiative recombination brings about the recombination center is hard to be introduced into a resultant crystal. The reason is as follows. An (Al)GaAs base layer would strain toward contraction of lattice by carbon doping and is in a state where the crystal thereof readily degrades by this contractive strain. On the other hand, when indium or antimony having a larger atomic radius than that of Ga and As is added, its lattice strains toward expansion rather than contraction since this make the crystal stable to the excess lattice vibration which is caused by non-radiative recombination. It is also important that the lattice constant of the base layer is within the predetermined range with respect to the lattice constant of the emitter layer and the lattice constant of the collector layer. In addition, the reduction in the concentration of impurity hydrogen in the carbon doped (Al)GaAs base layer also effectively contributes the improvement of lifetime of the heterojunction bipolar transistor.

[0011] Although the importance of regulation of the degree of lattice strain of the base was explained herein, regulation of the degree of lattice strain becomes important similarly as to the emitter layer since non-radiative recombination may occur also in the emitter layer. Further, it is also acceptable that the lattice constant of

the collector layer can be changed by adding an equal electric charge-element to adjust the degree of lattice strain of the base layer with respect to the collector layer.

Translation of [Fig.1], [Fig. 8], [Fig. 9] and [Explanation of Letters or Numerals] in Brief description of the Drawings

[Fig. 1] Fig. 1 is a cross sectional view showing a construction of a heterojunction bipolar transistor in an example of the present invention.

[Fig. 8] Fig. 8 is a diagram showing the relationship between a lifetime of a heterojunction bipolar transistor and a degree of lattice strain.

[Fig. 9] Fig. 9 is a diagram showing a change with time of a current amplification factor of heterojunction bipolar transistors of the present invention and the conventional one.

[Explanation of Letters or Numerals]

S Semi-insulating GaAs Substrate

1 n-Type GaAs Collector Buffer Layer

2 Undoped GaAs Collector Layer

3 Carbon Doped p-Type GaAs Base Layer

4 n-Type $Al_{0.3}Ga_{0.7}As$ Emitter Layer

5 n-Type InGaAs Emitter-cap Layer

6 Emitter Electrode

7 Base Electrode

8 Collector Electrode

9 Isolation layer

10 Insulating Film

12 Phosphorus Added, Undoped GaAs Collector Layer

13 Indium Added, Carbon Doped p-Type GaAs Base Layer

14 Phosphorus Added, n-Type $Al_{0.3}Ga_{0.7}As$ Emitter Layer

23 Carbon Doped (InGaAs/GaAs) n(≥ 1)-Laminating Strained Base Layer

Drawings of Fig.1, Fig. 8 and Fig. 9

Fig. 1 【図1】

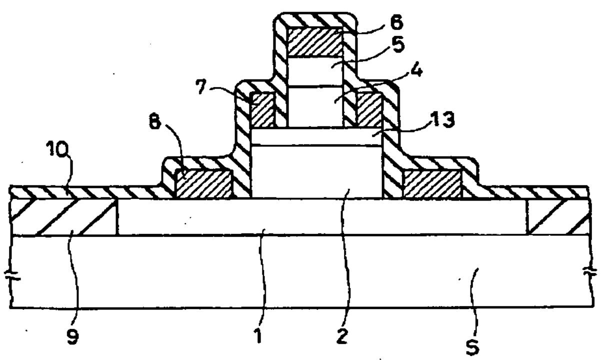

Fig. 8 【図8】

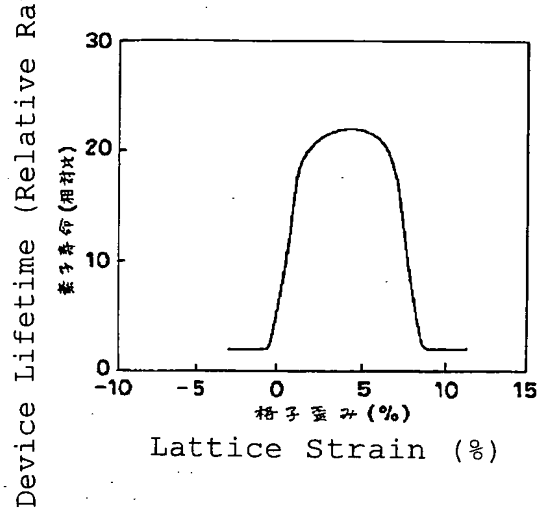

Fig. 9 【図9】